Report to the Army Corps of Engineers

Coralville Lake Project

Deer Exclosure Update

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By

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Project History:

The deer exclosure project was conceived in Spring, 1997 as a cooperative research project between the Army Corps of Engineers and Steve Hendrix. In January, 2000, sampling for the project was assumed by Hendrix Ecological Consulting (HEC). The Army Corps of Engineers is responsibility for maintenance of the deer exclosures and HEC is responsible for sampling vegetation in the exclosures and adjacent control plots (see below).

Four sites in the vicinity of the Coralville Dam were chosen for construction of the deer exclosures (Figure 1). These sites were designated as: **1**) Tailwater (TW), **2**) West Overlook, (WO) **3**) Linder Point East (LPE), and **4**) Linder Point West (LPW). At each site, a 15m X 15 m exclosure consisting of 2 m tall fencing was constructed. An adjacent 15 m X 15m area was marked off with posts and served as a control area. Construction of the exclosures proceeded slowly during the summer of 1997; exclosures were completed in November, 1997. Gates were added to the exclosures and rebar stakes to be used in height profile sampling (see Results below) were added to exclosures and control plots in Spring, 1998. We sampled the study sites in July, 1998 and July, 2000 for height profiles of vegetation. In Spring, 1999, we initiated a study to establish baseline information on species richness and abundance of spring flora in the plots; in Spring, 2000 a thorough survey of the herbaceous vegetation in control plots and exclosures was undertaken. The previous report (Jan, 2000) also includes data on distribution and size of trees in plots.

Project Methods

1. Height Profile - Height profile sampling was used to examine differences in the vertical distribution and amounts of vegetation in exclosures and control plots. The process consists of holding a 3 m rod marked off in 0.25 m intervals at 16 regularly spaced sampling points in the plots (Figure 2). Sampling points were permanently marked with rebar. The number of touches of vegetation, and height interval of the touches was noted. Height profile data was sampled once in July 1998 and July 2000.

Data from the height profile measurements was analyzed using a modified Shannon-Weiner Index of Diversity in which height intervals are considered equivalent to "species" and the number of touches in each height interval is equivalent to "number of individuals." This method takes into account not only the number of different height intervals with vegetation but the distribution of touches of vegetation across the height intervals. If deer are having an impact on the vegetation in control plots compared to exclosures one should see a greater "diversity" of vegetation in exclosures. This greater diversity can come about by *either* an increase in the number of height intervals with vegetation touched *or* an increase in the evenness of touches in exclosures across height intervals (e.g. more touches in height intervals where deer would have been expected to browse compared to control plots) or both.

The formula for calculating the diversity indices for each plot is:

$$\text{Height Diversity Index} = - \Sigma\, p_i \bullet \text{Log}_2 p_i$$

Where p_i = the proportion of total touches in a plot in height interval i

After determining the p_i for each height interval, the $\log_{10}$ of the p_i is taken. After each p_i is multiplied by each $\log_2 p_i$, these are summed to give the Shannon-Weiner Index of height diversity.

I used two-way analysis of variance to test for differences between control and exclosure plots and years in height diversity index, evenness, number of height categories with touches, and total number of touches. Preliminary analyses indicated that interaction terms were insignificant; these were dropped from the models and analyses were rerun. Differences between main effects were tested with Tukey's Studentized Range (SAS, 8.0).

2. Analysis of the Herbaceous Flora – In Spring, 2000 exclosure and control plots at three of the study sites (Tailwater, West Overlook, and Linder Point East) were visited on five occasions: March 26-29, April 12-14, April 29, and May 19, and June 19. At each visit presence/absence of different species of herbaceous vegetation was surveyed. A one-way analysis of variance examined for differences between control plots and exclosures in number of species of herbs.

Project Results, Discussion, and Recommendations:

1. Height Profiles: Statistical analysis of height profile data show a significant difference in SWI of height diversity between plots ($F_{1,13} = 7.42$, $P = 0.017$). Exclosures had significantly higher foliage height diversity than control plots (Table 1). Raw Data from all plots is given in Appendix 1. In 1998, there was a statistical trend for greater height diversity indices in exclosures compared to controls (at a probability of $p = 0.06$), but this differences might been partially due to initial differences in plots before exclosures were constructed. The present overall increase in differences between exclosures and control plots can be reasonably attributed to white-tail deer herbivory, the primary browsers in the area. There is large variation, however, between sites (Fig. 3) in changes in SWI over time which will be discussed below.

The increase in foliage height diversity in the exclosures is the result of increased evenness in the distribution of foliage among height intervals ($F_{1,13} = 6.88$, $P = 0.021$) in exclosures compared to control plots (Table 1). As with changes in the overall SWI, there is large variation between sites in changes in evenness over time (Fig. 4). There was also a trend for vegetation in exclosures to be distributed among a greater number of height intervals than vegetation in control plots ($F_{1,13} = 3.37$, $P = 0.089$) (Table 1), but no

significant difference between exclosures and control plots in total number of touches (Table 1). These data indicate that white-tail deer herbivory is resulting in a redistribution of vegetation with less vegetation between 0.50 – 2.0 m and more vegetation below and above this zone. Such a change is confirmed by visual inspection of height-profile diagrams of each plot (Figs. 5-8), although some plots show a much stronger effect than others (see below).

There was no significant variation attributed to differences between years in any of the analyses.

Table 1. Mean Shannon-Weiner Index foliage height diversity index (SWI), evenness, number of height intervals with vegetation, and total number of touches (± s.e.) in control and exclosure plots. N= 8 for all values.

Variable	Control Plots	Exclosures
SWI	2.00 ± 0.19	2.57 ± 0.07
Evenness	0.76 ± 0.04	0.88 ± 0.02
No. Intervals	6.87 ± 0.81	8.75 ± 0.56
No. Touches	35.0 ± 5.6	38.6 ± 5.8

Variation between sites: The strongest effect of the exclosure is at the Linder Point East site where over time both overall SWI (Fig. 3a) and evenness (Fig. 4a) increased in the exclosure and decreased in the control plot. At the nearby Linder Point West site, both SWI (Fig. 3b) and evenness (Fig. 4b) decreased in the exclosure and increased slightly in the control plot over time. The West Overlook site had the most touches of vegetation and has a more open canopy than the other sites. At this site over time both overall SWI (Fig. 3c) and evenness (Fig. 4c) increased in the exclosure and decreased in the control plot (as predicted if the effects of deer herbivory are detectable). The Tailwater East site is a north-facing slope with little vegetation in either the control or exclosure. Small changes in the amount and distribution of vegetation between years likely account for the anomalous results in which, contrary to predictions, overall SWI (Fig. 3d) and evenness (Fig. 4d) *decreased* in the exclosure and *increased* in the control plot. In conclusion, two of the sites show effects of deer herbivory on the vegetation but two sites do not.

Conclusions and Recommendations: At this time, potential effects of deer herbivory on the distribution of vegetation should continue to be monitored. Although effects of deer appear to be occurring at two site, the lack of effects at the other two sites suggest that deer herbivory is not a major problem throughout the area surrounding the dam. I recommend that height profiles be resample in 2002.

2. Analysis of Herbaceous Flora

The one-way analysis of variance revealed a trend ($F_{1,6} = 3.82$, $P = 0.098$) for greater richness of herbaceous species in exclosures (mean = 19.2) compared to control

plots (mean = 16.5) (Table 2) in 2000. The 2000 survey discovered more species than the 1999 (exclosures: mean = 10.25, controls: mean = 7.5), possibly because surveys in 2000 continued through May and June. The previous shorter survey of only the spring flora revealed significant differences between exclosures and controls, but this difference is not sustained in the present sample.

Table 2. Number of species of herbs at the study sites.

Location	**No. Herbaceous Species**	
	Control	Exclosure
Tailwater East	19	18
West Overlook	13	19
Linder Point East	18	20
Linder Point West	16	20

Presence of species in exclosures and plots (Table 3) indicate that in addition to new species found in 2000, some species tentatively identified in 1999 were not seen in 2000.

Recommendation: Herbaceous plant species richness should continue to be monitored at the sites. Compete seasonal surveys should be conducted in 2001 to confirm or refute the trend seen in the present year's data. At this time it does not appear that white-tail deer are having a measureable effect on herbaceous species richness.

Table 3. Plant species present in exclosures and control plots, 2000. Dates indicate first sighting.

Plant Name	Description/Common Name	Family	TW - E	TW-C	WO-E	WO-C	LPE-E	LPE-C	LPW-E	LPW-C
Anemone quinquefolia?	confirm ID	Ranunculaceae	X	X						
Anemonella thalictroides	rue anemone	Ranunculaceae	3/29/00	4/14/00**			X		4/13/00	
Arisaema triphyllum	jack-in-the-pulpit	Araceae		4/29/00**				4/29/00**		
Asplenium platyneuron	ebony spleenwort	Polypodiaceae			4/14/00	4/29/00	X		?	?
Aster?		Asteraceae					X		X	
Barbarea vulgaris	common mustard	Brassicaceae	X	X	4/29/00	4/29/00	X	3/29/00	4/29/00	3/29/00
Botrychium dissectum ***	small grape fern	Ophioglossaceae	4/14/00**	4/29/00**	4/29/00**	4/29/00**	4/29/00**	4/29/00**	4/29/00**	
Botrychium virginianum	Rattlesnake fern	Ophioglossaceae	4/14/00							
Juniperus tree seeding		Cupressaceae			X	X				
Claytonia virginica	Spring beauty	Portulacaceae	3/29/00	3/26/00	4/14/00	X	3/29/00	X	3/29/00	3/29/00
Cryptotaenia candadensis	honewort				6/19/00		6/19/00	6/19/00	6/19/00	6/19/00
Cystopteris fragilis.	common bladder ferm		4/29/00	4/29/00						
Cystopteris spp.	bladder fern		3/29/00	4/14/00	X		3/29/00**	4/12/00		X?
Dicentra cucullaria	Dutchman's Breeches	Fumariaceae	3/29/00	3/26/00	3/29/00**		?3/29/00**	3/26/00**	3/29/00	3/29/00
Erigeron annuus					6/19/00					
Galium aparine	creeping chickweed	Rubianceae	5/19/00		4/29/00	4/29/00	5/19/00	5/19/00	4/29/00	5/19/00
Galium boreale	erect chickweed	Rubiaceae	4/14/00	3/26/00	3/29/00	6/19/00	3/29/00	3/29/00	3/29/00**	3/29/00**
Impatiens spp.	jewelweed	Balsaminaceae					4/29/00**	4/29/00		
Hepatica acutiloba		Ranunculaceae	3/29/00						X	
Osmorhiza claytonia		Apiaceae			5/19/00		6/19/00	6/19/00	5/19/00	5/19/00
Osmorhiza lonistylus		Apiaceae		5/19/00			5/19/00		5/19/00	
Iodanthus pinnatifidus		Brassicaceae					4/29/00**			
Phlox divaricata		Polemoniaceae	4/29/00**	4/29/00**						
Podophyllum peltatum	May-apple	Berberidaceae	4/14/00**	4/14/00			4/29/00**			4/29/00**
Polemonium repens	Jacob's ladder	Polemoniaceae	4/29/00	3/26/00**						3/29/00**
Potentilla arguta		Rosaceae			6/19/00	6/19/00				
Potentillla spp.									6/19/00	
Ribes spp	gooseberry	Saxifragaceae	3/29/00	3/26/00			X	4/13/00	4/13/00	3/29/00
Ranunculus abortivus	small-flowered crowfoot	Ranunculaceae		4/14/00**	4/29/00**	4/14/00**	4/14/00**	4/13/00*	4/13/00**	4/13/00**
Sanguinaria canadensis	bloodroot	Papaveraceae	4/14/00	4/29/00					4/13/00	X
Sanicula gregaria	Sanicula; snakeroot	Apiaceae	6/19/00	6/19/01	5/19/00	5/19/00	5/19/00	5/19/00	5/19/00	5/19/00
Sanicula canadensis	Sanicula; snakeroot	Apiaceae		5/19/00	6/19/00	6/19/00				

Senecio plattenis					5/19/00	5/19/00				
Solidago spp		Asteraceae			?4/29/00**		?4/29/00**	4/29/00**	4/29/00**	
Taraxacum officinale	dandelion	Asteraceae			3/29/00	3/29/00	3/29/00	3/26/00	3/29/00	3/29/00
Trillium spp.	wake robin	Liliaceae	X							
unk. 3 (grass)	small grass - like bluegrass	Poaceae					X	3/26/00**	X	3/29/00
unk. 4 (grass)	large course- diff from unk.3	Poaceae				4/29/00 +		3/26/00	4/13/00	
unk. 5 (sedge)	sedge	Cyperaceae		4/29/00						
unk. 6 (rose)	wild rose?	Rosaceae	4/14/00		4/29/00		4/29/00**	4/29/00	4/29/00	4/29/00
Viola sororia	wood violet	Violaceae	4/14/00	4/14/00	3/26/00	3/26/00	4/12/00	4/12/00	4/13/00	? 3/29/00

? = not id'ed for sure

**New to plot in 2000

X = seen in 99 but not 00

Appendix 1. Shannon-Wiener foliage height diversity index (SWI), evenness, number of height intervals with vegetation, and total number of touches in control and exclosure plots.

Year	Plot	Treatment	SWI	Evenness	# Ht Intervals (out of 12)	Total No. Touches
1998	Linder Point E	Control	1.9497	0.7430	7	31
1998	Linder Point E	Exclosure	2.5.763	0.8256	11	42
1998	Linder Point W	Control	1.9272	0.7278	7	23
1998	Linder Point W	Exclosure	2.8510	0.9381	9	34
1998	W. Overlook	Control	2.7583	0.9236	9	41
1998	W. Overlook	Exclosure	2.3521	0.8418	8	49
1998	Tailwater E	Control	1.6167	0.6834	5	17
1998	Tailwater E	Exclosure	2.5850	0.9398	7	12
2000	Linder Point E	Control	1.1684	0.5365	4	50
2000	Linder Point E	Exclosure	2.6435	0.9788	9	44
2000	Linder Point W	Control	2.0373	0.7639	7	35
2000	Linder Point W	Exclosure	2.3449	0.8778	7	46
2000	W. Overlook	Control	2.7437	0.8714	11	63
2000	W. Overlook	Exclosure	2.8209	0.8835	11	63
2000	Tailwater E	Control	1.8282	0.8102	5	20
2000	Tailwater E	Exclosure	2.3955	0.8400	8	19